Close-Range Photogrammetry

By Neffra Matthews, Geographer; and Tom Noble, Cartographer; BLM, National Science and Technology Center

Photogrammetry (the art, science, and technology of obtaining reliable information from photographic images) has traditionally utilized commercial, large-format, aerial photography. This technology can be used to measure, document, or monitor almost anything that is visible within a photograph. Photogrammetry can be divided into categories, depending on the distance of the camera from the subject.

Aerial photogrammetry typically refers to oblique or vertical images acquired from distances that are greater than 300 m. This limitation is imposed by the Federal Aviation Administration. When aerial photography is flown at a height of 305 m (1,000 feet) above mean terrain with a 153-mm focal length lens, the result is photography at 1:2,000 scale. The smallest object that can be detected is 5 cm.

Close-range (also referred to as terrestrial or ground-based) photogrammetry (CRP) has an object-to-camera distance of less than 300 m. A variety of cameras and platforms may be used to obtain the photographic images to be used in CRP processing, thus theoretically there is no limit to the resolution that can be achieved.

How the Pictures Are Taken

An advantage that CRP can have over other types of measurement techniques is that the subject being measured does not have to actually be touched. This can be vital to documentation of delicate biological soil crusts, rare archaeological and paleontological sites, areas of soil erosion, and even vegetation. In addition, areas not easily accessible or that contain hazardous materials may be documented safely by using close-range photogrammetry. To facilitate photographing these subjects, a variety of methods can be used, including cameras housed in remote-controlled airplanes, suspended below helium-filled blimps, and mounted on tripods.

How Close-Range Photogrammetry Varies

As mentioned previously, higher resolutions, which in turn yield higher accuracy measurements, can be achieved from images taken closer to the subject. In addition, the perspective of the photographs is not limited to a directly overhead or slightly oblique view. Photographs taken at or near ground level provide a look at resources that cannot be achieved from traditional aerial photos.

What Else Is Needed

The same requirements that exist for a successful aerial photogrammetric project (camera calibration, control coordinates for camera orientation, and stereo-photo pairs) are also required by CRP. Conventional survey techniques (such as Global Positioning Systems) may be adequate for close-range projects where the ground sample distance (or pixel size) is larger than the accuracies achievable by these methods. Unfortunately, past attempts at CRP have seen limited success by the resource community. This is because of the expense of calibrated film cameras, the need for cumbersomely collected control points, and the often difficult prospect of processing nonstandard imagery in the photogrammetric workflow.

Photographs taken at closer distances with higher Ground Sample Distance (GSD) can further complicate the situation. In situations where the object-to-camera distance is 50 m or less, it is possible to achieve pixel resolutions that far exceed the level of control that can be easily collected by conventional methods.

A New Approach

Three-dimensional measuring and modeling software (3DMM) is a relatively new tool that can be integrated into the traditional photogrammetric process, forming a hybrid process that meets many of the requirements in a nontraditional way. Camera calibration is an integral part of the 3DMM software and can be performed on any camera that can be set to a repeatable focal length (for example, at infinity). The software can use many photographs, taken from many different perspectives (it is not restricted to stereo pairs). In addition, the 3DMM software has the ability to mark circular objects at the subpixel level. Subpixel marking is an established method that allows for a least squares determination of the center of a group of pixels that represent a circle. The end result is a point marked to a higher precision than is humanly possible. For example, given a GSD of 0.25 mm, targets marked to 1/10th of a pixel equate to 0.025 mm.

Another feature of the software is the ability to use coded targets. Coded targets are essentially circular bar codes with a center circle and arcs of varying lengths surrounding it. This point number will be associated with a specific target on every photo it appears on, making referencing points across many photos nearly automatic. Once a sufficient number of points is marked and referenced between photos, a least squares analysis is performed and the relative location and orientation of every photo can be resolved, greatly enhancing the accuracy of computed coordinates.

The tools required for field collection of microtopographic data using the hybrid method are a digital camera and fairly inexpensive software. This process is very robust and can be applied to a large variety of resource issues and used by persons with a wide level of technical expertise. Once photographs have been acquired and oriented with 3DMM software, the resulting camera orientations can be imported directly into a softcopy photogrammetric workstation, as the cumbersome process of control point collection and aerotriangulation has been circumvented.

Although traditional photogrammetric control is not required to orient the stereo photographs, it can be utilized to tie the topography into a real-world coordinate system.

The hybrid process provides previously unrealized flexibility in planning close-range stereoscopic photo layout (i.e., more and higher resolution stereo pairs and oblique stereo photography).

Products

The result of the data generated from softcopy photogrammetric analysis yields detailed digital terrain data. These data consist of a dense grid of x, y, and z coordinate points that can be accurate to ±0.5 mm, depending on project scale. Digital, three-dimensional surfaces and detailed microtopographic contour maps can be produced from the terrain data for areas as large as 5 m^2. Larger areas can also benefit from this type of documentation; however, positional accuracies may be reduced depending on a variety of factors.

Contact

Neffra Matthews, Geographer
Bureau of Land Management
National Science and Technology Center
Denver Federal Center
Building 50, P.O. Box 25047
Denver, CO 80225-0047
Phone: 303-236-0176
Fax: 303-236-6564
Email: *Neffra_Matthews@blm.gov*